SCIENCE FOR GLASS PRODUCTION

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OPERATION OF A GLASS-MELTING FURNACE WITH A HEAT-INSULATED MELTING TANK

V. V. Fokin,[1] V. I. Kondrashov,[1] N. A. Khovanskaya,[1] and Yu. V. Zverev[1]

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The operating advantages of a glass-melting furnace with a thermally insulated melting tank are considered. A scheme of thermal insulation is presented. The efficiency of the heat insulation of the melting tank in the production of glass with decreased light transmission is noted.

Operating experience both in Russia and abroad proves that thermal insulation of glass-melting tanks not only ensures substantial fuel savings but also contributes to a longer operating time and improves the quality of the produced glass.

However, up to recent times, complete thermal insulation of melting tanks in the domestic glass industry was implemented only in furnaces producing container or special glass. Furnaces for sheet glass usually have partial thermal insulation of the tank walls and roof. The tank bottom is not insulated because of the risk of premature destruction of it.

The Saratov Institute of Glass, in the course of furnace reconstruction in 1988, performed complete thermal insulation of the melting tank of the ÉPKS-4000 glass-melting furnace for production of polished sheet glass using the method of sheet molding on a metal melt.

The furnace has four pairs of burners. The total surface area of the furnace bottom is 174 m^2, and the area of the surface of the heated part is 96.5 m^2. The melting-tank length is 17.4 m, width 7.2 m, and depth 1.3 m.

The heat insulation of the melting tank was done in the following way: the first section of the roof is sealed with refractory phosphate daubing 5 – 7 mm thick; the second, third, and fourth sections are sealed with the daubing; next a quartz sand layer (25 – 30 mm), chamotte fiber plates (100 mm), and aluminum sheet (1.5 mm) are laid.

The melting-tank walls are insulated with aerated aluminochromium phosphate concrete blocks. The seals between the Bakor beams of the tank are open.

For melting tank-bottom (upward), first steel sheet 10 mm thick is laid, over it aerated aluminochromium phosphate concrete 300 mm thick, over it aluminosilicate refractory 300 mm thick, then korvishite tiles 100 mm thick on a mortar, and the last layer consists of Bakor tiles 100 mm thick on a mortar (Fig. 1).

The main purpose of the complete heat insulation of the melting tank was to improve product quality.

It is known that at temperatures below 1200°C, the glass-melt viscosity is sharply decreased [1], which causes the formation of bottom layers of low-mobility melt. Due to this, the active volume of the furnace is decreased, and the homogenization of the glass melt deteriorates. Moreover, when the temperature in the melting tank fluctuates, the low-mobility layers become temporarily heated, activated, and involved in the glass-melt flow, which decreases the glass-melt homogeneity and the quality of the produced glass with respect to the optical parameters and gas inclusions.

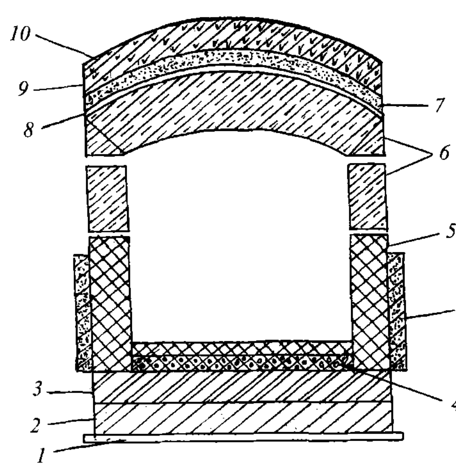

Fig. 1. Scheme of heat insulation of the melting tank: *1*) steel sheet, *2*) aerated aluminochromium phosphate concrete; *3*) aluminosilicate refractory; *4*) korvishite; *5*) Bakor; *6*) dinas; *7*) quartz sand; *8*) sealing daubing; *9*) chamotte fiber plates; *10*) aluminum sheet.

[1] Saratov Institute of Glass, Saratov, Russia.

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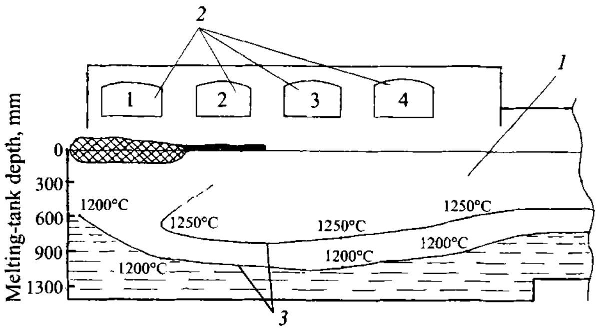

Fig. 2. Position of the low-mobility glass melt in the melting tank of the ÉPKS-4000 glass-melting furnace: *1*) melting tank; *2*) burners; *3*) isotherms.

Our study of high-temperature industrial furnaces for sheet glass showed that 17 – 20% of the volume of their melting tanks in the bottom zones is occupied by glass melt whose temperature is below 1200°C. This parameter for the ÉPKS-4000 furnace was equal to 23%. The most unfavorable zone in this respect is the end of the melting tank, especially if the cooling-tank depth beyond the knuckle is smaller than the melting-tank depth.

In developing initial requirements for the ÉPKS-4000 furnace reconstruction, the authors set the glass-melt temperature at the bottom at the end of the melting tank to be no less than 1200°C. This condition should be fulfilled by the capability of insulation of the melting-tank bottom and walls.

The technological and heat-engineering aspects of the furnace were investigated in periods of its operation with a noninsulated and an insulated melting tank.

The present paper considers the factors that have an effect on the quality of the glass.

Heat insulation of the melting tank made it possible to significantly increase the glass-melt temperature in the bottom zones of the furnace and to eliminate the low-mobility layer (Fig. 2).

Table 1 reflects the glass-melt temperature distribution over the depth of the melting tank with and without heat insulation.

The glass-melt temperature was recorded in different cross sections of the melting tank over its depth employing a movable thermocouple and stationary bottom thermocouples placed under the Bakor tiles.

Thanks to the heat insulation, the glass-melt temperature increased significantly in the whole melting-tank volume. The bottom-layer temperature increased most of all (by 95°C in the kwellpunkt zone and by 60°C at the end of the melting tank) and reached a level above the "critical value." The temperature homogeneity of the glass melt improved across the entire melting-tank depth and across the working-channel depth.

The maximum temperature difference between the top and the bottom layers decreased from 310°C to 225°C at the kwellpunkt and from 230 to 175°C at the end of the melting tank.

TABLE 1

Level with regard to the glass-melt surface	Temperature of glass melt, °C			
	in the kwellpunkt zone		at the end of the melting tank	
	noninsulated melting tank	insulated melting tank	noninsulated	insulated
0.0	1500	1510	1410	1415
0.4	1410	1435	1280	1320
0.8	1330	1370	1230	1270
1.3	1190	1285	1180	1240

Studies and computations of the convective flows of the glass melt showed that their activity had increased. The maximum velocity of the direct flow in the melting tank increased by 12.3% and was equal to 23.9 m/h, and the flow rate of the glass melt increased by 18.8%.

Thus, thermal insulation made it possible to eliminate the slowly moving glass-melt layer and increase the active volume of the tank. As a consequence, the glass-melt homogeneity improved, which had a positive effect on the quality of the produced glass.

By the average statistical data for a year, the optical-distortion angle in the glass was 30.4° and the number of deviations from the standard regime was 1.7 when the melting tank was not insulated. The same parameters for the furnace with an insulated tank were 34.5° and 0.2, respectively.

No additional complications were observed in operating the furnace with a heat-insulated melting tank. Owing to the increased thermal inertia, furnace operation was more stable, and the effect of fluctuations in gas consumption, output, the batch/cullet ratio, etc. had a less strong effect on the position of the melting-zone boundaries, the temperature of the glass melt produced, and the product quality.

The campaign of the furnace lasted 6 years 10 months. An inspection of the melting-tank bottom after the furnace was stopped for cold overhaul showed that the multilayer refractory lining had become monolithic and had virtually no damages (except for the swirling zone). After replacement of several upper-row tiles in the swirling zone, the furnace bottom was left unchanged for a second campaign.

Thus, complete heat insulation of glass-melting tanks significantly increases their efficiency and withstands long-term service without failures, provided that special instructions for furnace lining and removal of the furnace from operation are complied with. Heat insulation of melting tanks is especially effective in the production of glass with decreased light transmission.

The Saratov Institute of Glass offers technical assistance to manufacturers who would like to use our experience.

REFERENCES

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